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Nontechnical Issues Regarding the Use of Adaptive Site Management

This chapter considers whether currently existing regulations and regulatory guidance from the U. S. Environmental Protection Agency (EPA) and the Department of Defense (DoD) allow for the use of adaptive site management (ASM). All the mechanisms for changing and modifying selected remedies—formal amendments to Records of Decision (ROD), RCRA permit modifications, various other documents such as the CERCLA Explanation of Significant Differences, contingency RODs, five-year reviews, impracticability waivers, and optimization studies, among others—can be encompassed by ASM. In addition to identifying significant regulatory and policy issues, the chapter also considers other relevant nontechnical issues including the role of the public and long-term stewardship (which is synonymous with long-term management in DoD guidance) in ASM. To make changes in remedial strategies, it is necessary to achieve consensus among stakeholders, including the lead regulatory agency, the responsible party, the affected public, and public or private transferees. The ASM tools described in Chapter 3 are critical to help demonstrate to diverse stakeholder groups that changes are warranted. Finally, long-term stewardship figures prominently in ASM and is an area in which federal facilities are only now gaining experience. These topics are discussed minimally in recent Navy guidance on optimization of remedies (NAVFAC, 2001). Several areas where supplemental guidance will be needed to fully adopt ASM are highlighted below.

REGULATORY AND POLICY ISSUES

Federal facility cleanups must comply with the Superfund cleanup requirements, as well as any more stringent state requirements (Section 120 of CERCLA and 10 U.S.C. § 2701). Superfund requires that each remedy be protective and attain the "applicable or relevant and appropriate requirements" (ARARs) provided in federal and state environmental laws. Protectiveness can be achieved by reducing the soil, groundwater, or surface water contaminant concentrations to below health-based levels or by preventing exposure without removing or destroying the chemicals at the site. Historically, cleanup goals for groundwater have been set at or below the drinking water standard for those contaminants that have one, or at a concentration within the risk range of 10^{-4} to 10^{-6} for carcinogens and a hazard index of less than 1.0 for noncarcinogens (EPA, 1990). A typical standard for contaminants in groundwater is in the range of 0.5 parts per billion to low parts per billion (NRC, 1994, 1999). Ecological risks or other site-specific factors may result in more stringent cleanup goals. ARARs, including drinking water standards, can be waived, for example, if among other reasons implementing the remedy would result in a greater risk to human health and the environment, compliance with the requirement is technically impracticable from an engineering perspective, or another remedial action would attain the performance equivalent of the federal or state requirement.

The lead agency for making cleanup decisions and the enforcing regulatory agency are different depending on whether the site (and associated facility) is on the National Priorities List (NPL) and on the relevant regulation used to guide cleanup. DoD acts as the lead agency for its sites regulated under CERCLA, although the agency must follow EPA cleanup guidance (DoD, 1999). EPA is the regulator only for those sites actually on the NPL. In practice, there may be DoD cleanups where EPA guidance is not as rigorously followed when EPA is not overseeing the activity (CPEO, 2002). At a federal facility, the remedy is selected by the head of the relevant department, although EPA must concur; if the federal agency and EPA are unable to reach agreement, the remedy is selected by EPA [CERCLA Section 120(e)(4)].

DoD also addresses many of its non-NPL sites under CERCLA, but in those cases, lead regulatory authority is held by the state. The enforcement role of EPA at these sites is greatly reduced, although EPA plays a role at closing bases because CERCLA Section 120(h) requires EPA to review transfers. There are a few sites, such as the Naval Ammunition Support Detachment Vieques, where DoD has invited EPA to oversee cleanup at non-NPL sites.

At DoD's RCRA sites, EPA may be the lead regulator—that is, it may issue administrative orders—if it has not delegated to the state/territory the relevant RCRA authority such as corrective action. In addition, many states assert regulatory authority under state hazardous waste laws. For example, at Rocky Mountain Arsenal, Colorado has regulatory authority throughout the process, including post-ROD remedy decisions.

Current Guidance on Optimizing and Changing Remedies and Remedial Goals

The greatest utility of using ASM lies in the ability to make changes over time as new information on site conditions and on the effectiveness of remedies becomes available. The approach identifies periods during which decisions can be made regarding the optimization of existing remedies, the changing of remedies, and the addition of new technologies to speed restoration—even if the existing remedy is maintaining protectiveness. Significant new information might include post-ROD, pre-implementation sampling concerning the extent or degree of contamination or a risk assessment that indicates the remedial action is unacceptable or overly protective. Typically, minor or insignificant adjustments do not require public comments (EPA, 1999a). For sites where contamination remains onsite following implementation of the remedy—such as NPL sites with dense nonaqueous phase liquid (DNAPL) contamination—the CERCLA five-year review process provides a long-term opportunity to make changes to the chosen remedy (although as discussed later, it is rarely used in this capacity).

Changing remedies over time is already addressed in a number of EPA regulations, policies, and guidance as well as in DoD guidance (Air Force, 2001; DoD, 2001a; NAVFAC, 2001). For example, EPA regulations (EPA, 1990) and policy (EPA, 1996a) clearly provide for modification of the remedy when new information is obtained that could affect the implementation of that remedy. The party seeking the change (e.g., the Navy) must generate the information needed to justify such a change. EPA guidance states that the final decision on whether to change the remedy (even at federal restoration sites) rests with EPA (EPA, 1996a,b).

Changing and optimizing remedies are widely acknowledged on a policy level as well. A number of guidance documents require potentially responsible parties (PRPs), including federal facilities, to seek to optimize the site remedial action. For example, DoD's Closeout Guidance (which cites Air Force, 2001, and EPA, 1996a) states that "emphasis should be placed on optimization" as early in the process as possible, and the remedy should be changed if new information supports it.

Thus, there are no apparent legal or regulatory prohibitions to using ASM for making decisions about optimizing or changing remedies. In fact, the approach appears to be consistent with current DoD trends toward experiential optimization. The ASM flowchart described in Chapter 2 includes specific questions that should be asked during critical decision-making periods, which goes beyond the most recent guidance document developed for experiential optimization of cleanup at Navy facilities (NAVFAC, 2001).

EPA regulations also allow for remedial goals to be changed. The most prominent example, in the case of contaminated groundwater, is a technical impracticability (TI) waiver under Superfund or RCRA, which can be issued at sites where remedies are not meeting cleanup goals (EPA, 1993). If granted an impracticability waiver pursuant to EPA's existing policy, the PRP must implement an alternative remedial action, which may include a new remedial goal or containment of the plume. Any alternative remedial strategy that leaves contamination onsite must remain in effect at Superfund sites so long as it is protective of human health and the environment, which has to be reassessed every five years. If a new non-health-based remedial action goal is set, then no further action would be required once this new goal is attained. Box 6-1 describes the elements that must accompany an application for a technical impracticability waiver.

To fully embrace an ASM approach, DoD should adopt a policy of applying new technologies that might attain the original cleanup goals at Superfund sites that have received technical impracticability waivers or where cleanup is considered impracticable. This could serve to stimulate research, to minimize future operation and maintenance costs, and/or to reduce risks such that additional land uses would be permitted. It is possible that at many sites the economic benefits of site redevelopment may exceed the cost of additional cleanup that would allow for a broader range of land uses.

Although the above recommendation represents an opportunity to update EPA's technical impracticability guidance to be consistent with ASM, its utility may be limited because there is little evidence that DoD intends to apply for TI waivers on a regular basis. In fact, recent NAVFAC guidance (NAVFAC, 2001) clearly favors the consideration of

BOX 6-1
Technical Impracticability for Contaminated Groundwater Sites

Technical impracticability refers to a situation "where achieving groundwater cleanup objectives is not possible from an engineering perspective" (EPA, 1993). Although there is no specific timeframe that defines impracticability, the guidance has been interpreted to mean very long timeframes (e.g., longer than 100 years) that are indicative of hydrogeologic or contaminant-related constraints to remediation. Technical impracticability (TI) waivers consider the feasibility, reliability, scale, and safety of the remedial option. Some cleanup approaches may be technically possible, but the scale of the operation might be of such magnitude that it is not technically practicable.

Requests for technical impracticability waivers are encouraged early during corrective action (e.g., during facility characterization) if a site has hydrogeologic or chemical-related features that are known to present cleanup limitations. EPA has made it clear that poor cleanup performance due to inadequate remedial design is not sufficient justification for a technical impracticability waiver. Rather, the waiver is usually based upon the presence of nonaqueous phase liquids (NAPL) and their persistence and location, as well as upon the technologies that are available to clean them up. Although the amount of characterization needed for a TI waiver will vary on a site-by-site basis, the waiver application should include (EPA, 1993):

- the spatial area over which the TI decision would apply,
- the specific groundwater cleanup objectives that are considered technically impracticable to achieve,
- the conceptual site model that describes geology, hydrology, groundwater contamination sources, transport, and fate,
- an evaluation of the "restoration potential" of the TI zone,
- cost estimates,
- any additional information EPA or the state program deems necessary (e.g., the difference in the timeframe for cleanup with and without the TI waiver), and
- an alternative remedial strategy.

The alternative remedial strategy should be technically practicable, control the sources of contamination, and prevent migration of contamination beyond the zone associated with the technical impracticability determination. It must be capable of achieving the groundwater cleanup objectives outside the zone associated with the technical impracticability determination, and it must be consistent with the overall cleanup goals for the facility.

The obligations for monitoring and containment within the TI zone continue as long as necessary to protect human health and the environment, or in the case of RCRA sites, until such time that cleanup within the TI zone becomes technically practicable and the cleanup levels are achieved throughout the entire plume.

new remedies rather than TI waivers if the original remedy reaches the point of diminishing returns. Indeed, in the last eight years, EPA has issued only 29 technical impracticability waivers to private and public PRPs (only 30 have been sought). These low numbers may reflect the high transaction cost involved in obtaining such waivers, the likely potential public backlash, and the shift since 1990 toward selecting containment, natural attenuation, and other remedies perceived to be less expensive. For example, changing to a containment remedy achieves the same cost reduction goal as a TI waiver but without permanently changing the ultimate cleanup goal for the site. Thus, many regulators may prefer requiring reasonable source control measures coupled with long-term containment of the residual over providing TI waivers.

Policy Barriers to Adaptive Site Management

Despite the fact that the current DoD and EPA guidance encourages optimization and that ASM is inherently consistent with the CERCLA and RCRA frameworks, there are potential policy barriers to adopting ASM on a widespread basis. First, as discussed in Chapter 2, there is no specific requirement under CERCLA to reconsider remedies over time that are ineffective in reaching cleanup goals as long as they are protective of human health and the environment (EPA, 1993, 2001a). Thus, there is relatively little incentive to optimize remedies once they are in place. The same is not true of RCRA sites, where EPA may revisit the remedy not just for protectiveness and reliability, but also if subsequent advances in remediation technology make attainment of the original cleanup standards technically practicable (EPA, 1993). Because the legal obligation to initiate a cleanup at RCRA sites (called a corrective action) is implemented through a hazardous waste permit or administrative order, EPA's authority to require periodic updating of the remedial action at RCRA sites may be stronger from a legal point of view. (It should be noted, however, that there is little evidence to date that EPA has utilized this authority to revisit the remedy at RCRA sites.) At a CERCLA site, a remedial project manager (RPM) would not by law be prevented from reconsidering an ineffective remedy. However, pressure to close out sites and rely on containment and institutional controls generally preclude this type of activity on any measurable scale. If ASM is to be adopted, such reconsideration must not just be allowed but should be required.

EPA's policy of not requiring additional remedial actions at CERCLA sites is based on statutory provisions and policy judgments that do not apply to federal facilities. For example, CERCLA's covenant-not-to-sue provision provides an explicit legal release of future liability if a private PRP successfully implements the remedy selected by EPA. Historically, judicial actions have generally favored finality rather than open-ended obligations. There is a long-standing policy of encouraging private parties to implement CERCLA remedies by providing this type of finality. However, because EPA cannot bring a judicial enforcement action against a federal facility, the covenant-not-to-sue does not apply to military sites. In fact, a strong public policy argument can be made that federal facilities should take the lead in encouraging the development and application of innovative technologies to hazardous waste sites where the remedy is not reaching cleanup goals. Clearly, because there is a different policy for RCRA sites than for CERCLA private sector sites, there could be a different policy for federal restoration sites that would better embrace the principles of ASM. This approach would be similar to that taken in a number of environmental statutes. For example, the Clean Water Act sets nonenforceable goals (e.g., zero discharge), but requires the step-by-step implementation of technologies to attain industry-specific discharge limits that are periodically made more stringent if new technology is developed.

Second, it has been argued that amending the ROD to change the remedy to reflect new data and advances in technologies is a "cumbersome process" (NRC, 1997), and for this reason, approaches such as ASM that encourage reconsideration of remedies over time may be less likely to succeed. However, there has been improvement over the last several years, such that EPA has updated a total of 300 remedy decisions through the end of the 1999 fiscal year, thereby saving an estimated $1.4 billion, although the costs at some sites have increased (EPA, 2001b). There were 156 updates to soil remedies and 129 updates to groundwater remedies; federal facilities updated 18 remedial actions. Over 62 percent of the changed remedial actions still involved treatment, and 17 percent were changed from groundwater treatment to monitored natural attenuation. These changes generally occurred in the remedial design stage. Most remedy changes were modifications to the original remedy, not installation of a completely new remedy.

Finally, there is little guidance available to Navy RPMs to assist them in evaluating whether remedies are operating optimally or whether remedies are unlikely to attain site-specific cleanup goals and need to be modified to ensure protectiveness—a key decision period in ASM (MDP3). For example, none of the existing guidance on changing the remedy (EPA, 1996a), on technical impracticability (EPA, 1993), on the five-year review (EPA, 2001a), and on site closeout (DoD, 1999) provides a systematic scientific approach to assessing optimization or to determining when groundwater contaminant concentration reduction has leveled off at a concentration significantly higher than the cleanup goal. The existing guidance is also inadequate to address monitoring needs after remedy implementation (MDP2). The same documents mentioned above explicitly state that additional data will be needed, but they do not provide concrete information on the types of data that are useful and when data gathering should be initiated. NAVFAC (2001) goes a long way toward providing some of this guidance and, as recommended in Chapter 2, should be considered for formal adoption by the Navy. However, this report does not discuss the research track of ASM (discussed in Chapter 4) or the reconsideration of remedies during long-term stewardship (MDP4), and both of these issues are absent from other guidance documents as well (such as the EPA reports on optimization).

PUBLIC PARTICIPATION

Since at least the early 1980s, the federal government and most other stakeholder groups have recognized public participation as an essential part of the process for cleaning up contaminated sites (EPA, 2000a). The mechanisms and timing of public involvement, however, have evolved over time. The ASM model suggests the need to update public participation methodologies once again.

CERCLA and other statutes that govern the cleanup of contaminated sites emphasize the public's right to influence the selection of remedies. The general process at federal facilities is for the lead agency to list a series of remedial options at each operable unit and propose a preferred alternative. Members of the public are then given the opportunity to comment on the proposal in writing during a brief public comment period or in person at one or more public meetings conducted during that period. This approach, however, proved inadequate at many contaminated sites, particularly large, complex federal facilities such as those owned by the Departments of Energy and Defense. Thus, in the early 1990s, the Federal Facilities Environmental Restoration Dialogue Committee (FFERDC) brought together federal agencies, state, tribal, and local government representatives, and community activists to explore ways to improve public participation in the federal cleanup process. FFERDC found that "where a public involvement process is mandated by law, the public often perceives that the process is used to defend decisions already made without meaningful dialogue with the affected public" (FFERDC, 1993). FFERDC participants labeled this model "Decide, Announce, Defend."

FFERDC laid the groundwork for a major expansion in the role of the affected public in cleanup decision making. It set a new standard—"early and often"—for public participation, going beyond the public comment opportunities required just before remedy selection (FFERDC, 1996). It recommended "regular, early, and effective public participation in federal cleanup programs" (FFERDC, 1993). This led to the creation of site-specific advisory boards at federal facilities across the United States. DoD established more than 292 Restoration Advisory Boards (RABs) to oversee environmental response at more than 356 present and former facilities. The Navy supports at least 91 such boards (Navy, 1999, RAB Supplement, p. 7). RABs provide opportunities for the public to learn about and comment on cleanup activities well beyond the minimal requirements of CERCLA and other hazardous waste laws. Although the implementation of RABs has been uneven across the military, the Navy has been vigilant and consistent in its overall efforts to involve the public in decision making. Like citizen advisory boards in other domains, the success of a RAB depends on a combination of factors, including the composition of the board and the commitment of its members, the formal and practical extent of the committee's role and influence, and the social and interpersonal environment created by the agency, facilitators, and members (Renn et al., 1995; DOE, 1997a; Chess and Purcell, 1999; Lynn et al., 2000; Murdock and Sexton, 2002).

Changing Role of Public Participation

As site cleanup has progressed in the United States, more sites are being remediated with containment and institutional controls such that significant levels of contamination remain onsite (see Figure 1-8). This trend in hazardous waste cleanup calls for another shift in the mode of public participation. Just as regulatory oversight and technological review are necessary until a site is closed out, at properties where the selected remedy is designed to leave contamination in place, public participation should not only occur early and often, but as long as contamination remains onsite at levels above cleanup goals. The rationale is simple: if the public is required to be involved in selecting the remedy because it may affect their health and well-being, then the public must similarly be involved in any significant decision to change that remedy or land use because these decisions also may affect their health and well-being.

The adoption of ASM is expected to make the public's role in cleanup more essential over time because new decisions that require their interaction will arise periodically as cleanup progresses. For example, the public may play a role in the evaluation and experimentation element of ASM, as discussed in Chapter 4. The Moffett Field Restoration Advisory Board has shown ongoing interest in and support for the Permeable Reactive Barrier (PRB) demonstration being conducted at Moffett. In fact, RAB members recently urged that monitoring at the demonstration site continue even after depletion of dedicated research funding. Furthermore, the Technical Assistance Grant consultant employed by the Silicon Valley Toxics Coalition—a local community group that has participated in Moffett oversight since 1989—took part in a national task force on permeable reactive barriers organized by the Interstate Technology Regulatory Council Working Group (P. Strauss, P. M. Strauss & Associates, personal communication, 2002).

Public participation, which is particularly critical during MDP4 of ASM, is expected to occur regularly and over the long term at sites where contamination remains in place. Personnel and contractors representing both responsible parties and regulatory agencies tend to change every few years, and in fact responsibility for cleanup is often transferred to new organizations. This can lead to a loss of institutional memory that often only public participants can fill. Continuity will require that the collaborative decision-making process involving responsible parties, regulators, and stakeholders established before remedy selection continue as long as significant contamination remains onsite. This requires that regulators approve and the public oversee cleanup decisions made after the signing of RODs, which is sometimes not the modus operandi at military cleanups. Achieving a high level of public participation years after the initial studies and the signing of the ROD may prove difficult, but it is essential to the long-term success of cleanup.

Current Trends in Public Participation During Long-Term Stewardship

Existing guidance on the latter stages of site cleanup states that there should be public involvement in updates to remedial actions, five-year reviews, technical impracticability determinations, and the site closeout decision. The degree of public involvement in changing a remedy depends upon whether the change is minor (in which case virtually no prior public involvement is required) or is a modification of the existing remedy (in which case some public involvement is necessary, but not as much as for a complete change in remedy) (EPA, 1999a). The five-year review guidance states that when no contaminants remain onsite above levels that allow for unrestricted use and unlimited exposure, a determination of closeout must be subjected to public comment (EPA, 2001a). However, it is not clear whether a public meeting is required, and the extent to which this requirement applies to non-NPL federal sites. EPA's technical impracticability guidance states that any alternative remedies must be selected using the existing CERCLA and RCRA remedy selection processes, which include public comments.

Despite these specific calls for public involvement, public interest in the cleanup process tends to peak at certain times, such as when threats to public health are discovered or disclosed, or when facilities are scheduled for closure and transfer. When remediation becomes routine, community interest tends to decline. Some RABs, such as at Moffett Field—the original model used by the Federal Facilities Environmental Restoration Dialogue Committee—have started to meet less frequently. Others, such as the RAB at the Philadelphia Navy complex, have lost members, particularly those who attended as volunteers. Thus, the RAB model must evolve to accommodate operation and maintenance activities occurring long after the signing of the ROD.

As mentioned above, it is standard to involve the public in long-term site management by inviting public comment on certain proposed changes, such as Explanations of Significant Difference, or on recurring review documents (i.e., five-year reviews). Depending upon the legal status of the cleanup, the latter usually occurs about four years after remedial construction starts, which may be several years after the remedy selection process—the initial focus of public involvement. Not surprisingly, the committee's review of over 30 recent five-year review reports found public involvement to be limited, although there are exceptions. For example, in 2000, at the Shattuck Chemical Company site in Denver, community-based critics, supported by high-level elected officials, used the five-year review to overturn the original remedy (SC&A, Inc., 1999). In 1999, the process of writing a five-year review spurred the residents of San Diego's Tierrasanta neighborhood—a former defense site contaminated with unexploded ordnance—to identify shortcomings in the educational risk management activities carried out in support of the U.S. Army Corps of Engineers cleanup of the site (Spehn, 2001). And at Hamilton Field, California, the San Francisco Bay Region Water Quality Control

Board received comments from an adjacent developer, the city of Novato, and a regional environmental organization regarding the Corps' proposed plan to reopen a landfill remedy (California RWQCB, 2001).

There are sites where public oversight on long-term review has not been encouraged. The Department of Energy's (DOE) second five-year review report for the Weldon Spring Site Remedial Action Project contained "no evidence of community involvement" (Missouri DNR, 2002). At a site in Palo Alto, CA, no five-year review has been initiated for extraction systems (California EPA, 2001), which has been attributed to the layoff of key people within the company as well as other expense-cutting measures (R. Moss, Barron Park Association Foundation, personal communication, 2002). At the MEW Study Area in Mountain View, CA, the responsible parties undertook an effective, comprehensive two-year review of source control and regional extraction remedies in 2000, but without notifying neighboring communities, leading to substantial controversy in 2001 when the neighbors became aware of the activity (Siegel, 2001).

EPA's new guidance for the five-year review (EPA, 2001a) offers detailed suggestions for involving the public in the review process, but overall it discourages the reopening of remedial decisions unless a remedy is shown to not be protective of human health and the environment. The guidance does not adequately address the challenge of engaging public participants who have become less involved in ongoing cleanup because of the amount of the time that has passed.

Strategies for Long-Term Public Involvement

The generally successful RAB model can be adapted to give the public a longer-lasting role in both regular review and any unscheduled reconsideration of remediation activity. Currently there is no DoD-wide guidance outlining how to involve the public following the selection of remedies at contaminated sites. The DoD's late-2001 promise to promulgate a rule, by mid-2003, to govern the operation of RABs (Defense Environmental Alert, 2001) provides an excellent opportunity to update long-term community relations policies. Indeed, the Army has developed guidance underscoring the importance of engaging the public after the signing of the ROD (USAEC, 1998). This guidance specifically identifies five-year reviews, remedy performance evaluations, monitoring to evaluate natural attenuation, decisions to discontinue or decrease treatment systems, technical impracticability waivers, maintenance and enforcement of institutional controls, demonstrations that the remedy is operating properly and successfully, and site close-out reports as benefiting from greater public involvement. The Army's guidance stresses that "if a RAB adjourns because there is no longer sufficient, sustained community interest, the installation must ensure that its overall community involvement programs provide for continued stakeholder input, and the installation must continue to monitor for any subsequent changes in community interest to revive the RAB." Without question, this implies much more than simply publishing a newspaper notice when site managers have a new plan or report available for public review.

Three approaches represent potential mechanisms for ensuring long-term public involvement; they may be used individually or in combination. First, once RABs determine that their remedy-selection work is done, they could schedule, with the support of both responsible parties and regulators, annual "reunions." Former board members and other members of the public could arrange to receive presentations on the status of long-term stewardship activities. Such reunions would be an excellent time to solicit public comment on any decisions that may be up for reconsideration. If changes are proposed in the middle of the year, the "reunion" participants would be invited to a special meeting.

Second, community oversight could be turned over to other government agencies. In locations where remaining contamination represents a visible health threat, the local health department might be best situated to assume such oversight. Where property has been transferred, local planning jurisdictions or recipient federal agencies could provide oversight for the contamination and its remedies. Grassroots involvement could be incorporated into other community relations activities conducted by such agencies. If local health or planning departments are given these new duties, federal funds need to be available to ensure that the departments have the appropriate expertise.

Third, at active federal facilities, RABs could be transformed into broader environmental advisory boards whose scope would include environmental compliance, pollution prevention, conservation, and other environmental issues. In many communities, residents actually care more about ongoing environmental issues than cleanup, but rarely has the military been willing to involve the public in resolving those problems. Should members of the public be given the opportunity to advise on base environmental affairs in general, they would be well situated to provide advice should cleanup decisions be reopened. Groups that are monitoring the compliance of effluent and emissions standards could easily monitor land use controls that are part of a cleanup remedy. DoD and the armed services have been considering this third path, but it raises internal organizational and financial obstacles. It may take legislative intervention to authorize the improved integration of cleanup activity with other environmental programs.

Whatever mechanism is utilized to encourage continuing public involvement, lead agencies should tailor their public notification activities to the level of proposed activities. For example, no special notification should be necessary for minor modifications to optimize a remedy, unless the physical location of a component is moved such that it will raise concerns among the public. On the other hand, if remedies in operation reach a point of diminishing returns without reaching cleanup goals, then the public should have the opportunity to review proposals to shut down those remedies and to recommend new strategies designed to achieve the original cleanup goals. Where remedies include long-term containment or treatment operations, the public should be provided with quantitative data that will allow them to evaluate remedial decisions being proposed by the responsible parties and regulatory agencies. Utilizing some of the tools described elsewhere in this report, lead agencies should publish data describing treatment results (such as trends in contaminant concentration versus time, mass removed versus time, or cost of mass removed versus time) and the specific monitoring values utilized to determine the effectiveness of the remedial action. The public is unlikely to comment constructively—in fact, they may not even take part in the process—if other decision makers are not providing a complete and comprehensible picture of the state of the cleanup.

The goal of cleanup is to protect public health and the environment, and the public's role continues as long as contamination remains in place at levels that pose a potential risk. The concerned, affected public should be made aware of the progress of remedies, they should have access to comprehensible summaries of innovative alternative technologies, and they should have the opportunity to present concerns and offer advice early enough to influence decisions.

LONG-TERM STEWARDSHIP: AN INTEGRAL PART OF ASM

As demonstrated in Chapter 1, more remedies today are being selected that utilize containment and institutional controls rather than treatment of the contaminant source. Institutional controls include covenants, zoning restrictions, well drilling bans, and public advisories that limit public access to residual contamination. Along with physical controls such as fences and buffer zones, institutional controls and containment are referred to as land use controls. Residual contamination is expected to remain at these sites such that unrestricted use of soil, groundwater, and surface water will not be permitted. As a consequence, containment technologies, institutional controls, and physical controls must be maintained as long as the potential risk remains in order to protect human health and the environment. The activities needed to maintain such remedies collectively are called long-term stewardship.

There has been growing awareness of this long-term stewardship responsibility by the federal government, particularly within DOE. In 1997, DOE published the first comprehensive analysis of contamination generated by the production of nuclear weapons, in which it acknowledged that it will not be possible to remediate all sites for unrestricted use (DOE, 1997b). DOE then started planning for implementation of long-term stewardship by addressing information needs (ICF Kaiser, 1998), by identifying implementation issues (Probst and McGovern, 1998; NRC, 2000; DOE, 2001a), by describing the scope and cost (DOE, 1999; DOE, 2001b), by evaluating funding mechanisms (Bauer and Probst, 2000), by evaluating the role of local governments (Pendergrass and Kirshenberg, 2001), and by analyzing how long-term stewardship considerations have been factored into remedial decisions (DOE, 2001c). DOE has initiated efforts to develop a long-term stewardship strategic plan, to identify the ultimate responsibility for long-term stewardship, to engage the public in a dialog on long-term stewardship, and to participate in intra-agency discussions on long-term stewardship.

Long-term stewardship is an integral part of ASM. As shown in Figure 2-7, if residual contamination remains in place following an attainment of "response complete," then the site is subject to long-term stewardship. Long-term stewardship starts when remediation, disposal, or stabilization is complete, or, in the case of long-term remedial actions such as groundwater treatment, when the remedy is shown to be functioning properly. Long-term stewardship ensures that remediation remains effective for an extended, or possibly indefinite, period of time until residual hazards are reduced sufficiently to permit unrestricted use and unlimited access. ASM specifically requires that during long-term stewardship, the existing remedy be reconsidered periodically to determine if it could be optimized or if it should be replaced by a new technology that could lead to unrestricted use of the site. This might lead to the replacement of containment or institutional controls with a more active remedial system. The motivation for periodically reconsidering the remedy is to be able to reach site closeout, which is not possible unless contamination is permanently reduced to levels below that which pose an unacceptable human health or environmental risk. This reconsideration represents a significant departure from the way PRPs usually conduct long-term stewardship.

Basic Elements of Long-Term Stewardship

Long-term stewardship requires stewards, operations, information systems, research, public participation, and public education—all of which should be laid out in advance in a long-term stewardship plan (Oak Ridge, 1998, 1999; Probst and McGovern, 1998; Bauer and Probst, 2000; NRC, 2000). Stewards—those responsible for developing, implementing, and overseeing the activities necessary to maintain the remedy—should be selected based on the following criteria:

- appropriate technical expertise so that the remedy can be properly operated, maintained, monitored, evaluated, and modified to ensure protectiveness,
- knowledge of developing technologies so that a change to the remedy can be evaluated,
- ability to enforce land use controls,
- institutional longevity in order to be in existence as long as the remedy is needed,
- property ownership (e.g., federal government, local government, or private sector),
- longevity of the funding source,
- ability to oversee multiple sites for economies of scale,
- experience in public participation and public education and thus an ability to obtain public trust and confidence,
- ability to adapt to changing land use,
- institutional memory, and
- ability and authority to make decisions.

It is likely that not just one steward, but rather a consortium of stewards working through a coordinating group will be the most effective and efficient approach. Examples of potential stewards include the party responsible for the contamination, a new federal long-term stewardship agency, an existing federal agency assigned with long-term stewardship responsibility, a host state or a multi-state consortium, an insurance company, and a nonprofit organization. The goals in assigning responsibility for long-term stewardship to one or more entities are to ensure attentiveness to the long-term stewardship tasks, to achieve economies of scale, to utilize experienced personnel, to create an incentive to implement innovative technologies, and to increase public trust and confidence.

The "operations" element of long-term stewardship refers to those activities necessary to ensure the integrity of the engineering technologies, institutional controls, and physical controls, and it includes inspection, monitoring, maintenance, surveillance, modification, replacement, enforcement, and evaluation. The "information systems" element, which includes the maintenance of records of residual contamination, associated risks, and required long-term stewardship activities, must be maintained as long as the residual contamination poses a risk to human health and the environment. The "research" element is needed to understand such issues as the long-term performance of stabilization and containment technologies and the long-term migration of contaminants in order to reduce the cost of long-term stewardship and the risk of residual contamination.

Public participation is integral to the selection, implementation, and performance review of the remedy and to long-term stewardship activities. As discussed previously, engaging the public during long-term stewardship can be a challenge. Indeed, only engineering technologies, institutional controls, and physical controls (and not long-term stewardship operations) are described in a decision document, which is the major opportunity for public involvement (see Figure 1-1). Members of the public who live around restoration sites need assurance that the remedial actions are operated in a manner that maintains effectiveness over a very long time period. Along with public participation, public education is necessary to ensure that the nature and risk of the residual contamination and the resultant types of land use controls are understood. This understanding will facilitate the enforcement of land use controls.

One of the greatest obstacles to long-term stewardship is the lack of a stable source of funding, particularly one that is independent of budget cycles. EPA and the state regulatory agencies do not have the authority to consistently fund long-term stewardship activities because such money must be appropriated by Congress every year. Lump sum payments and long-term contracts can be entered into, but federal entities are also subject to Congress appropriating money for the project. EPA and state agencies often do not have the administrative resources or, at times, the willingness to require long-term stewardship. This problem tends to increase with the passage of time as competing issues arise that require funding and attention. Fortunately, EPA, the Navy, and other federal agencies are exploring the use of trusts and other lump sum payment devices. Box 6-2 contains a discussion of funding options for long-term stewardship.

In order to ensure the long-term institutional management of contaminated sites, the Navy should perform all of the basic elements of long-term stewardship as a matter of policy. Additionally, long-term stewardship should be integrated into the remedial decision-making process such that site characterization, remedial alternative assessments,

BOX 6-2
Funding Options for Long-Term Stewardship

The uncertainty of the length and scope of long-term stewardship presents a challenge for identifying sustainable funding mechanisms. Currently, the federal budget process provides funding for long-term stewardship for which the federal government is responsible. However, the annual budget process does not guarantee funding for long-term stewardship, which is a concern to local governments and stakeholders.

The following four funding options (English et al., 1997; Probst and McGovern, 1998; Bauer and Probst, 2000; Defense Environmental Alert, 2000; Department of Energy, 2001b) are representative of those being considered as sustainable funding sources for long-term stewardship:

Annual congressional appropriations. The federal agency requests funds for long-term stewardship on an annual basis, and Congress appropriates what it considers necessary. This is not a guaranteed funding mechanism and can be affected by changing national priorities.

Trust funds. A long-term stewardship trust fund produces a predictable source of funds. A trust fund can be created at the national, state, or local level. New legislation may be necessary to create a trust fund. The initial funding source can be congressional appropriations, fees, or sales of assets.

Fees/sales of assets. Government agencies might create revenue by selling assets or by providing services for which a fee is charged. The income from sales or services can be collected in a fund to support long-term stewardship. Because this income now goes to the general Treasury, new legislation will be needed.

Public–private partnerships. Private entities can lease government assets at below-market rates in return for assuming responsibility for long-term stewardship. This option also may require new legislation.

and decision documents evaluate long-term stewardship as part of the remedy (Pendergrass and Kirshenberg, 2001). **Because all federal agencies with environmental restoration programs face this issue, ideally the Administration should convene an interagency task force to develop a government-wide policy and mission for long-term stewardship at federal sites.** This group, which should include independent experts and representatives of major stakeholder groups, could recommend how to integrate the costs and the challenges of long-term stewardship into the decision-making and budgeting processes and into any new legislation (Probst and McGovern, 1998). This policy would help develop a clear model for how to pay for long-term stewardship activities.

Limitations of Land Use Controls

The rationale for MDP4 is to focus PRPs on eventual site closeout rather than on the indefinite maintenance of land use controls. In the case of contaminants such as recalcitrant organic compounds, heavy metals, and radionuclides, land use controls may be required for hundreds or thousands of years. Over this timeframe, the cost and viability of land use controls are highly uncertain. Cleanup to unrestricted use removes the uncertainty surrounding the long-term effectiveness of land use controls.

Many documents have noted the limitations of land use controls, particularly institutional controls, for a variety of reasons (NRC, 1999, 2000; English et al., 1997; Pendergrass, 2000; Pendergrass and Kirshenberg, 2001). For example, local governments often are responsible for implementing institutional controls but usually are not consulted in evaluating and selecting a remedy; thus, they may not have the resources or authority to implement the controls. In other cases, RODs include only general descriptions of institutional controls, which makes implementation difficult. Monitoring of institutional controls is poorly understood and thus may not be done frequently enough to identify weaknesses before failure. And very often the public does not understand the nature of the hazard or the required maintenance of institutional controls, which adversely affects the rigor with which the institutional controls can be enforced.

Nonetheless, for the present time, land use controls will be part of many site remedies. Better information is needed on the number of public and private sites that rely on or will rely on land use controls so that

DoD can develop a consistent approach to estimating the annual and life-cycle cost of maintaining such controls and to evaluating their performance (Probst and McGovern, 1998; NEPI, 1999). Research should be conducted on where and under what conditions land use controls are successful or unsuccessful. This information will be helpful in determining the national infrastructure and information needs for long-term stewardship, in defining the local and federal government roles in long-term stewardship, and in determining how to fund long-term stewardship and how to design future facilities with long-term stewardship in mind. As described in Box 6-3, DoD has established an overall framework for implementing, documenting, and managing land use controls for both closing and active facilities (DoD 1997a,b, 2001b) that should help to overcome many of the limitations of these controls.

BOX 6-3
DoD Policy on Land Use Controls
Source: DoD (2001b).

The Department of Defense policy for land use controls for active facilities and those being transferred out of federal control requires:

- using multiple, overlapping land use controls,
- modifying or terminating land use controls after going through the same process used to set the land use controls in the first place,
- considering the costs of implementing and maintaining the land use controls in the remedy determination,
- maintaining a central database of properties restricted by land use controls and using state registries where they exist,
- using existing processes and mechanisms in the development, implementation, and management of land use controls,
- managing and maintaining land use controls at the local level where possible,
- reviewing the maintenance of land use controls and notifying the installation officials immediately if a land use control is being violated,
- identifying in the proposed plan, record of decision, or other decision documents the future land use assumption that was used to develop the remedy, the specific land use restrictions necessitated by the selected remedy, and the possible mechanisms for implementing and enforcing those use restrictions, and
- developing enforceable land use controls based on state property and environmental law.

Revisiting the Remedy During the Five-Year Review

MDP4 of ASM provides an opportunity for the remedy to be re-evaluated to see if it still represents the optimum solution. In many cases, at the time of initial remedy selection, no technology may be available to clean up the site to unrestricted use at a reasonable cost. However, in ten or 20 years, such a technology may exist. Because of changing conditions, there may be opportunities to achieve the remedial goals for less money or in less time, or there may be an opportunity to achieve more aggressive remedial goals for the same money and time. Or the contaminated site may become sufficiently valuable to stake-holders in the future that they would be willing to support more cleanup than they were previously. Indeed, a study at DOE sites (Pendergrass and Kirshenberg, 2001) concluded that local governments prefer to remediate to levels that permit unrestricted use and to avoid long-term stewardship costs because land use restrictions may have long-term detrimental effects on economic development potential.

Five-year reviews are required by CERCLA at sites where contaminants remain above levels allowing unrestricted use. The purpose of these reviews is to determine if the selected remedy remains protective of human health and the environment. The three basic questions the five-year review is intended to answer are (1) is the remedy functioning as intended, (2) are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives still valid, and (3) has any other information (such as the discovery of new contamination) come to light that could call into question the protectiveness of the remedy (EPA, 2001a). The five-year review must specifically evaluate whether there has been a change in land use or exposure pathways. A remedy that was protective when it was adopted may not be protective in the future because of changes in land use or other site conditions. Five-year reviews generally include document reviews, reviews of cleanup standards, interviews, inspections, technology reviews, and preparation of a report summarizing the findings and recommendations. The five-year review is not considered a vehicle for adopting new technology.

EPA guidance (EPA, 2001a) provides useful tables describing situations where remedies are protective or not protective and provides several case examples. [Protectiveness is defined by the acceptable risk range of 10^{-6} to 10^{-4} for carcinogens and a hazard index of less than 1 for noncarcinogens (EPA, 2001a)]. Although the guidance is an improvement over prior guidance, it is still a general framework document. It does not suggest analytical methods that can be used to make decisions.

At federal facilities, the responsible federal agency performs the five-year review (even for properties already transferred to nonfederal ownership), although EPA has final authority at NPL sites over whether the five-year review is protective (EPA, 2001a). For non-NPL federal sites, EPA has no statutorily defined role, although EPA may comment on non-NPL sites on a case-by-case basis.

Once the five-year reviews are begun, they may be discontinued only if levels of contaminants allow for unrestricted use and unlimited exposure and if appropriate documentation and notification are given (EPA, 2001a). As a result, the five-year review may become a virtually perpetual requirement for sites where containment is the remedy or where the soil and groundwater cleanup goals are not met by the original remedial action. MDP4 of ASM provides an opportunity to use the five-year review as a mechanism for achieving site closeout. That is, in addition to asking whether the remedy remains protective during the five-year review, it should be asked whether there are newly available technologies that could expeditiously lead to site closeout—even if the current remedy is protective. If there were a more effective remedy available, the user would cycle back through the previous parts of ASM (see Figure 2-7). This consideration of new technologies that might optimize remedial performance and/or reduce lifecycle costs has been explicitly endorsed in new DOE guidance on the five-year review process (DOE, 2002).

MDP4 expands the scope of the five-year review process to include the basic elements of long-term stewardship—stewards, operations, information systems, research, public participation, and public education. First, the five-year reviews should evaluate operations with greater emphasis placed on enforcing and monitoring institutional controls, as there is little information available on their long-term effectiveness. EPA and DoD have initiated efforts to ensure that institutional controls are being properly implemented (EPA, 2000b; DoD, 2001b), but the detailed results are not yet available. During five-year reviews, the information system should be evaluated to see if the proper documents are being maintained in a manner accessible to the public. Typical documents that should be reviewed include RODs, state and federal environmental laws and regulations, remedial action reports, as-built drawings, monitoring data, operations and maintenance manuals and reports, institutional controls (e.g., deed notices, easements, and covenants), and community involvement plans. As discussed previously, there is little evidence of public involvement in long-term stewardship gleaned from previous five-year review reports. The involvement of the public in post-remediation decision making and activities should be evaluated as regularly as the remedy. The performance and capability of the stewards to fulfill the criteria outlined earlier should also be evaluated. Finally, the five-year review should evaluate the adequacy of funding for long-term stewardship. A lack of funding may be the cause for some of the deficiencies identified in other areas.

Expanding the role of the five-year review program to encompass remedy reconsideration should accompany general improvements to the program. Several EPA and independent studies have concluded that EPA's five-year reviews have inadequately supported the determination of "protective" (EPA, 1999b; Nakamura and Church, 2000; Probst and Konisky, 2001). Indeed, Resources for the Future (Probst and Konisky, 2001) reviewed 99 completed nonfederal remedial actions and found that at 48 percent of the sites, statements concerning the protectiveness of the remedy were insufficiently substantiated or were questionable because the remedies were not fully in place, were not functioning as intended, or were not likely to achieve remedial objectives. The committee's limited review of five-year review reports was consistent with these observations. Interestingly, although institutional controls were part of the remedial action at 61 percent of the sites, the institutional controls required were not fully implemented or had an "unknown" status at 28 percent of these sites (Probst and Konisky, 2001). Resources for the Future and others have recommended that EPA improve the quality of its five-year reviews.

Assessing Life-Cycle Costs

As discussed in Chapters 2 and 4, ASM may result in short-term cost increases at sites, partly because of the need for evaluation and experimentation activities that occur in parallel with remedy implementation. An important task is to determine whether the costs associated with ASM will be balanced by the savings that result from switching to a more efficient and effective technology or by overall life-cycle savings. There should be no debate that if a net savings (considering both implementation and life-cycle costs) can be achieved by changing to a remedy that is equally or more effective in meeting cleanup requirements, then the new remedial action should be implemented. For example, in some cases equivalent or superior long-term cleanup performance with lower life-cycle costs could be realized for groundwater if the remedy is converted from a pump-and-treat system to a passive, *in situ* system. However, making these cost assessments can be complicated. To date, few efforts have been made to determine whether remedies are cost-effective over the life span of a project, including design, construction, operations and maintenance, and closeout (EPA, 2000c). Furthermore, a selected remedy may initially be cost-effective, but over time new technologies may have been developed that could be implemented at decreased costs.

Ideally, the use of ASM necessitates that the full range of costs over the life of a chosen technology (e.g., those associated with materials and energy use and indirect pollutant emissions) be considered when determining whether and what additional site management is necessary [1]. The current practice at most sites (once the magnitude of site contamination, exposure, and potential risk have been characterized, and forecasts have been provided for how these might change under alternative technologies and management strategies) is to determine what the short-term costs of various different remedies will be to achieve the site cleanup goal. This is most effective when done for alternatives that are "comparably effective," (i.e., they accomplish the same end) (EPA, 1990). Factors other than immediate cost that may impact remedial choices, like stakeholder preferences and values, are generally addressed with group deliberation and participatory processes (Webler et al., 1995; NRC, 1996; Renn, 1999). These exercises could be improved by bringing more quantitative tools for valuation, cost-benefit analysis, and life-cycle analysis to bear on site management issues (Arrow et al., 1996; NRC, 1996; Farrow and Toman, 1999).

Although cost-benefit analysis is based on the well-established procedures of engineering economics, long-term costs from various operations (such as the management of treatment residuals, site monitoring, site security, and component depreciation) can be difficult to forecast. Evaluating the benefits associated with improvement in health, environmental quality, and community welfare likely to occur following implementation of different remedial options is even more difficult (Hull, 1993; Matthews and Lave, 2000). Some believe that cost-benefit analysis cannot capture the full range of social, political, and ethical factors that individuals and society consider when making environmental choices (e.g., Sagoff, 1988, 2000; Dower, 1990). It is not the intent of this report to delve into these complications, but rather to suggest that cost-benefit tools and life-cycle assessment have potential value for im-

[1] Although such full environmental "life-cycle assessment" has not to our knowledge been adopted in the evaluation of site cleanup alternatives, as it has for alternative product designs and processes (e.g., Curran, 1996; Graedel, 1998; Joshi, 1999), evaluations of the broader regional implications of alternative remediation strategies have been conducted (Schwarzenbach et al., 1999).

proving site management (for further discussion of this debate, see EPA, 1987; Freeman and Portney, 1989; Stroup, 1991; Sexton and Zimmerman, 1999; Fischhoff, 2000; Spash, 2000). The committee recognizes that such full-cost accounting may be too complex and costly to be incorporated into practical applications of ASM on a regular basis.

One important point is highlighted because it is a factor regardless of the complexity of the cost analysis that is undertaken—the issue of discount rates. Typically, feasibility studies use a 30-year net present value cost estimate that only includes direct costs of the remedy in decision making (EPA, 1988). The net present value methodology and the 30-year time frame may not be appropriate for comparing alternatives with long-term stewardship requirements that extend indefinitely (Portney and Weyant, 1999; Okrent and Pidgeon, 2000; DOE, 2001a; EPA, 2000c). This is because when usual discount rates and factors are used, the present value of future costs is essentially zero after several decades, such that an alternative with a lower initial construction cost almost always will have a lower life-cycle cost than an alternative with a higher initial cost. This is true even if the former alternative requires long-term stewardship costs indefinitely, and the latter only requires long-term stewardship costs for a short period of time. At a minimum, the sensitivity of cost analyses or predicted cost-benefit ratios to the selected discount rate should be evaluated.

To ensure that the full set of economic impacts is considered, the evaluation of cost effectiveness needs to be expanded to reflect indirect or opportunity costs that arise when a site's use is restricted (Pendergrass, 2000, 2001). These costs include lower property values, lower taxes, and lower social benefit to the community than if no land use restrictions existed. There also is the economic benefit in preventing or significantly minimizing potential future legal liability. The Navy, in conjunction with other federal agencies, should develop a life-cycle cost estimating technique that reflects the timeframes for which long-term stewardship will be needed, the indirect costs, and methods and procedures for appropriate discounting in computations of net present value for these applications.

Regulatory Oversight

Any changes made in remedies as a result of MDP4 during long-term stewardship should involve EPA and the state regulatory agency. This is necessary to preserve the checks and balances provided by the federal regulatory system and to ensure public confidence in the safety of the remedy. The existing regulatory programs provide shared authority for initial remedy selection between federal PRPs and regulatory authorities (EPA). The federal government has not developed a generally applicable, consistent position on the role of the regulatory agencies (federal or state) versus DoD in making post-ROD remedy modifications. There is no logical or policy rationale for using a different process for changing or terminating the remedy than for initial remedy selection. The continuing conflict and/or ambiguity over whether regulators may review decisions to change remedies should be resolved expeditiously. Without both public and regulatory review of DoD's remedial decisions, these decisions are unlikely to garner public support.

MAJOR CONCLUSIONS AND RECOMMENDATIONS

The underlying statutes on hazardous waste management are consistent with adaptive site management, and existing regulatory guidance could be modified to be more so. EPA's policy rationale for not requiring the implementation of additional technologies at CERCLA private sites is not applicable to federal facilities and should not be used as justification for not implementing ASM. The Navy and other federal agencies responsible for restoring sites should adopt ASM and develop agency-specific risk management policies and detailed guidance requiring that it be utilized. Many recent efforts (such as NAVFAC, 2001) are an attempt to provide some of the guidance that would be needed, although such documents must be strengthened to mention the research track of ASM and the reconsideration of remedies over the long term. The Navy may wish to issue its own technical impracticability guidance, either alone or as part of its ASM risk management policy, so that the consistency of technical impracticability waivers with ASM is clear.

The responsible federal agency should solicit public involvement during each of the four management decision periods of ASM. Changes to the remedy, the remedial goals, and future land use should be issued only after consideration of public comments, particularly the proposed easing of remedial objectives or suggestions that remedies be "turned off" before reaching established objectives. Although many individual guidance documents mention public involvement, there is no coherent public involvement process described in existing guidance or practiced in the field after remedy selection. As part of the RAB rule development process, DoD should work with regulators, public representatives, and other stakeholders to develop a menu of options for involving the public in the long-term oversight of cleanup programs at facilities where remedies or long-term stewardship activities are continuing.

During long-term stewardship, the remedy should be reconsidered as part of the five-year review, even if it is currently protective of human health and the environment. Because of changing conditions or the development of new technologies, there may be opportunities to achieve remedial goals for less money or in less time or achieve more aggressive remedial goals for the same money and time. Thus, it may be possible to replace land use controls with treatment remedies that will achieve unrestricted use and lead to site closeout. Only if unrestricted use levels are attained can the military and other agencies permanently remove sites from federal stewardship. The benefits of achieving site closeout include not only cost savings from reduced long-term operation and maintenance costs, but also increased taxes and minimization of potential future legal liability.

A government-wide policy for long-term stewardship (also known as long-term management) at federal sites is needed. This activity is needed to legitimize the basic elements of long-term stewardship and the expenditure of resources on these elements. As part of this effort, it will be important to develop a life-cycle cost estimating technique and appropriate discounting methods that reflect the timeframes for which long-term stewardship will be needed.

REFERENCES

Air Force. 2001. Final remedial process optimization handbook. Prepared for the Air Force Center for Environmental Excellence, Technology Transfer Division, Brooks Air Force Base, San Antonio, Texas, and Defense Logistics Agency, Environmental Safety Office, Fort Belvoir, VA.

Arrow, J. K., M. L. Cropper, G. C. Eads, R. W. Hahn, L. B. Lave, R. G. Noll, P. R. Portney, M. Russell, R. Schmalensee, V. K. Smith, and R. N. Stavins. 1996. Is there a role for benefit-cost analysis in environmental, health and safety regulation? Science 272:221–222.

Bauer, C., and K. N. Probst. 2000. Long-term stewardship of contaminated sites trust funds as mechanisms for financing and oversight. Washington, DC: Resources for the Future.

California EPA. 2001. Hillview-Porter regional program. Fact Sheet No. 19. Sacramento, CA: CA EPA Department of Toxic Substances Control.

California RWQCB. 2001. Cleanup and abatement order No. 01-139. CA RWQCB San Francisco Bay Region, November 28.

Center for Public Environmental Oversight (CPEO). 2002. Military list archive. Available at www.cpeo.org/lists/military/2002/msg00055.html.

Chess, C., and K. Purcell. 1999. Public participation and the environment: do we know what works? Environ. Sci. Technol. 33(16):2685–2692.

Curran, M.A. 1996. Environmental life-cycle assessment. New York: McGraw Hill.

Defense Environmental Alert. 2000. Federal trusts inappropriate for institutional controls. December 19, 2000.

Defense Environmental Alert. 2001. Pentagon agrees to develop Restoration Advisory Board Rule. December 18, 2001. Pp. 15–16.

Department of Defense (DoD). 1997a. Institutional controls: what they are and how they are used. BRAC Environmental Program Fact Sheet. Washington, DC: DoD Office of the Deputy Undersecretary of Defense (Environmental Security).

DoD. 1997b. Guidance responsibility for additional environmental cleanup after transfer of real property. Washington, DC: DoD Office of the Deputy Under Secretary of Defense (Acquisition and Technology).

DoD. 1999. The environmental site close out process guide. Washington, DC: EPA and DoD.

DoD. 2001a. Management guidance for the Defense Environmental Restoration Program. Washington, DC: DoD Office of the Deputy Under Secretary of Defense (Installations and Environment).

DoD. 2001b. Guidance on land use controls association with environmental restoration activities for active installations. 2001. Washington, DC: Department of Defense.

Department of Energy (DOE). 1997a. Site-specific advisory board initiative 1997, evaluation survey results. Washington, DC: DOE Office of Environmental Management,

DOE. 1997b. Linking legacies: connecting the cold war nuclear weapons production processes to their environmental consequences. Washington, DC: DOE Office of Environmental Management.

DOE. 1999. From cleanup to stewardship: a companion report to accelerating cleanup: paths to closure. Washington, DC: DOE Office of Environmental Management.

DOE. 2001a. Long-term stewardship study. Washington, DC: DOE Office of Environmental Management.

DOE. 2001b. A report to Congress on long-term stewardship. Washington, DC: DOE Office of Environmental Management.

DOE. 2001c. Long-term stewardship case study report, final draft. Washington, DC: DOE Office of Environmental Management.

DOE. 2002. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) five-year review guide. Washington, DC: DOE Office of Environmental Management.

Dower, R. 1990. Hazardous wastes in public policies for environmental protection 151, 180. Washington, DC: Resources for the Future.

English, M., D. Feldman, R. Inerfedl, and J. Lumley. 1997. Institutional controls at Superfund sites: a preliminary assessment of their efficacy and public acceptability. Knoxville, TN: University of Tennessee Energy, Environment, and Resources Center.

Environmental Protection Agency (EPA). 1987. Unfinished business: a comparative assessment of environmental problems. Washington, DC: EPA.

EPA. 1988. Guidance for conducting remedial investigations and feasibility studies under CERCLA, Interim Final. EPA/540/G-89/004. Washington, DC: EPA.

EPA. 1990. National oil pollution and hazardous substances contingency plan. Federal Register 56:8666, 8728.

EPA. 1993. Guidance for evaluating the technical impracticability of groundwater restoration. OSWER Dir. No. 9234.2-25. Washington, DC: EPA.

EPA. 1996a. Superfund reforms: updating remedy decisions. EPA 540-F-96-026, OSWER 9200.0-22. Washington, DC: EPA.

EPA. 1996b. Guidance for evaluation of federal agency demonstrations that remedial actions are operating properly and successfully under CERCLA Section 120(h)(3). Washington, DC: EPA.

EPA. 1999a. A guide to preparing Superfund proposed plans, record of decision, and other remedy selection decision documents. EPA 540-R-98-031. Washington, DC: EPA.

EPA. 1999b. Backlog of five-year reviews increased nearly three-fold. Washington, DC: EPA Office of Inspector General.

EPA. 2000a. Draft public involvement policy. Federal Register 65(250):82335-82345.

EPA. 2000b. Institutional controls: a site manager's guide to identifying, evaluating and selecting institutional controls at Superfund and RCRA corrective action cleanups. EPA 540-F-00-005, OSWER 9355.0-74FS-P. Washington, DC: EPA.

EPA. 2000c. A guide to developing and documenting cost estimates during the feasibility study. EPA 540-R-00-002, OSWER 9355.0-75. Washington, DC: EPA.

EPA. 2001b. Updating remedy decisions at select Superfund sites: cumulative summary report FY 1996 through FY 1999. EPA 540-R-01-002. Washington, DC: EPA.

EPA. 2001a. Comprehensive five-year review guidance. EPA 540-R-01-007. Washington, DC: EPA.

Farrow, S., and M. Toman. 1999. Using environmental benefit-cost analysis to improve government performance. Environment 41(2):12–15, 33–37.

FFERDC. 1993. Interim report of the Federal Facilities Environmental Dialogue Committee, The Keystone Center, February.

FFERDC. 1996. Final report of the Federal Facilities Environmental Dialogue Committee, The Keystone Center, April.

Fischhoff, B. 2000. Informed consent for eliciting environmental values. Environ. Sci. Technol. 34:1439–1444.

Freeman, M., and P. R. Portney. 1989. Economics and the rational management of risk. Discussion Paper CRM-89-5. Washington, DC: Resources for the Future.

Graedel, T. E. 1998. Streamlined life-cycle assessment. Upper Saddle River, NJ: Prentice Hall.

Hull, B. 1993. Valuing the environment: full-cost pricing-an inquiry and a goal 2-3. Report 103-93 to the Conf. Bd. of Canada, 1993.

ICF Kaiser Consulting Group. 1998. Managing data for long-term stewardship (working draft). Prepared for EG& G Technical Services of West Virginia under DOE Prime Contract No. DE-AC-95MC31346. Available at http://lts.apps.em.doe.gov/center/reports/doc1.html.

Joshi, S. 1999. Product environmental life cycle assessment using input-output techniques. Journal of Industrial Ecology 3(2/3):95–120.

Lynn, F. M., G. Busenberg, N. Cohen and C. Chess. 2000. Chemical industry's Community Advisory Panels: What has been their impact? Environ. Sci. Technol. 34(10):1881–1886.

Matthews, H. S., and L. B. Lave. 2000. Applications of environmental valuation for determining externality costs. Environ. Sci. Technol. 34(8):1390–1395.

Missouri Department of Natural Resources (DNR). 2002. Comments on the Weldon Spring site remedial action project second five-year review, August 2001.

Murdock, B. S., and K. Sexton. 2002. Promoting pollution prevention through community-industry dialogues: the good neighbor model in Minnesota. Environ. Sci. Technol. 36(10):2130–2137.

Nakamura, R., and T. Church. 2000. Reiventing Superfund: an assessment of EPA's administrative reforms. Washington, DC: National Academy of Public Administration.

National Environmental Policy Institute (NEPI). 1999. Rolling stewardship: beyond institutional controls. Washington, DC: NEPI.

National Research Council. 1994. Alternatives for ground water cleanup. Washington, DC: National Academy Press.

NRC. 1996. Understanding risk: informing decisions in a democratic society. Washington, DC: National Academy Press.

NRC. 1997. Innovations in ground water and soil cleanup: from concept to commercialization. Washington, DC: National Academy Press.

NRC. 1999. Environmental cleanup at navy facilities: risk-based methods. National Academy Press. Washington, D.C.

NRC. 2000. Long-term institutional management of U.S. Department of Energy legacy waste sites. Washington, DC: National Academy Press.

Navy. 1999. Defense Environmental Restoration Program Annual Report to Congress, Fiscal Year 1999.

NAVFAC. 2001. Guidance for optimizing remedial action operation (RAO). Special Report SR-2101-ENV. Prepared for the Naval Facilities Engineering Service Center. Research Triangle Park, NC: Radian International.

Oak Ridge Reservation End Use Working Group Stewardship Committee. July 1998. Stakeholder report on stewardship, Volume I. Washington, DC: DOE Environmental Management.

Oak Ridge Reservation End Use Working Group Stewardship Committee. December 1999. Stakeholder report on stewardship, Volume II. Washington, DC: DOE Environmental Management.

Okrent, D., and N. Pidgeon. 2000. Introduction: dilemmas in intergenerational versus intragenerational equity and risk policy. Risk Analysis 20(6):759–762.

Pendergrass, J. A. 2000. Protecting public health at Superfund sites: can institutional controls meet the challenge? Washington, DC: Environmental Law Institute.

Pendergrass, J. A., and S. Kirshenberg. 2001. Role of local government in long-term stewardship of DOE facilities. Washington, DC: Environmental Law Institute.

Portney, P. R., and J. P. Weyant (Eds.) 1999. Discounting and intergenerational equity. Washington, DC: Resources for the Future.

Probst, K. N., and M. H. McGovern. 1998. Long-term stewardship and the nuclear weapons complex: the challenge ahead. Washington, DC: Resources for the Future.

Probst, K. N., and D. M. Konisky. 2001. Superfund's future: what will it cost? Washington, DC: Resources for the Future.

Renn, O., T. Webler, and P. Wiedermann. 1995. Fairness and competence in citizen participation: evaluating models for environmental discourse. Boston, MA: Kluwer Academic Publishers.

Renn, O. 1999. A model for an analytic-deliberative process in risk management. Environ. Sci. Technol. 33(18):3049–3055.

Sagoff, M. 1988. The economy of the Earth: philosophy, law and the environment. Cambridge, UK, Cambridge University Press.

Sagoff, M. 2000. Environmental economics and the conflation of value and benefit. Environ. Sci. Technol. 34(8):1426–1432.

SC&A, Inc. 1999. Special five-year review report for Denver Radium Site, S.W. Shattuck Chemical Operable Unite #8, November 12, 1999.

Sexton, K., and R. Zimmerman. 1999. The emerging role of environmental justice in decision making. Pp. 419–443 In: Better environmental decisions: strategies for governments, businesses, and communities. K. Sexton, A. A. Marcus, K. W. Easter, and T. D. Burkhardt (eds.). Washington, DC: Island Press.

Schwarzenbach, R. C., R. W. Scholz, A. Heitzer, B. Staubli, and B. Grossmann. 1999. A regional perspective on contaminated site remediation: fate of materials and pollutants. Environ. Sci. Technol. 33(14):2305–2310.

Siegel, L. 2001. Emissions questioned at redeveloped MEW Superfund site. Center for Public Environmental Oversight. Available at http://www.cpeo.org/lists/brownfields/2001/msg00122.html.

Spash, C. L. 2000. Multiple value expression in contingent valuation: economics and ethics. Environ. Sci. Technol. 34(8):1433–1438.

Spehn, D. 2001. Presentation to the NRC Committee on Environmental Remediation at Naval Facilities. San Diego, CA. February 28.

Stroup, R. 1991. Chemophobia and activist environmental antidotes: is the cure more deadly than the disease? Economics and the Environment 193.

USAEC. 1998. U.S. Army restoration advisory board and technical assistance for public participation guidance. SFIM-AEC-ERP (200). Aberdeen Proving Ground, MD: Army Environmental Center.

Webler, T., H. Kastenholz, and O. Renn. 1995. Public participation in impact assessment: a social learning perspective. Environmental Impact Assessment Review 15:443–463.